Love, the Reason We Live: Romantic Love on the Human Body and Mind

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Romantic love is an idea both ubiquitous and timeless. Stories and songs of love span across ancient civilizations, biblical tales, mythologies, and are indisputably apparent in life today. Romantic love is present in most cultures. As such, love is thought to have a function in human biology. Feelings of love allow us to create bonds and relationships that facilitate courtship, mating, and ultimately the continuance of the human species. Romantic love is also evidently rooted in human physiology. This article is a review of studies of romantic love, as reasoned in evolutionary psychology, anthropology, and human physiology. This review explores the biological purpose and effects of love and concludes that love is more than a feeling. Love is a human drive. I discuss love in relation to the five senses and to neurophysiology to demonstrate that love physically affects our bodies and minds and to show how it does so. I then discuss lost love, or "heartbreak", and the bases for commonly held methods to move past or heal from it. Given the biological function of love, I propose that as surely as one can fall in love, one can fall out of it. This article shows the multifaceted nature of love and how it intricately takes form within us.

"One word frees us of all the weight and pain of life: That word is love."

— Sophocles

Love, a notion so pervasive and enduring proves to be ever such the mystery. Stories and songs of love span across ancient civilizations, mythologies, biblical tales, and are indisputably prevalent in life today. Love is often portrayed and perceived as life altering, life giving, and life defining. Love mends and heals as much as it severs and destroys. Love encourages peace as much as it cultivates war. Love is coveted and feared. There is a universal human fascination with love, intentional or unwitting, that associates its definition with happiness, success, and fulfillment. What about love is so enthralling? What about love merits millennia of human fixation and idealization? What about love lends its ability to permeate music, literature, and art and thus define culture and eras of time? What about love drives its documentation and display, regardless of the elation or misery it has procured? I believe that the unbounded predominance of love in human cultures suggests its importance in creating and cultivating human life.

Experiencing romantic love affects humans physiologically, and its purpose is explained in evolutionary psychology. Though complex and multifaceted in explanation, the basis is that humans love as a means to reproduce, thus fulfilling one of the universal ideas in biology which states that all organisms seek to reproduce to further their genes and thus their existence and niche in the world. This means that romantic love and all of the elation and despair that comes with it is but a biological process. Can this be true? Can something so enchanting and mysterious have its purpose rooted in science? Recent studies of romantic love found that love occurs in specific areas of the human brain, the ventral tegmental area and the caudate nucleus (Aron et al., 2005). This area of the brain is part of what is familiarly called the reptilian brain, which exists in all creatures. The ventral tegmental area and caudate nucleus are associated with motivation and reward systems which are activated to pursue basic needs of survival. It then follows that love, much less like an emotion, is likely more a basic human drive. A human instinct much like searching for food and water, romantic love facilitates the human mating system,

acting on individuals for their reproductive success. Love is rooted in our biology. We are made to love.

Love, even when viewed through the lens of science, has many facets. If love is a biological process then it follows that it should be universal in all humans and thus have certain foundational qualities. This means that though love may be experienced differently from person to person and defined distinctly from culture to culture, there should exist certain universals within love. This review, based on love's proposed universality, is a discussion of romantic love and its' intertwined physiological and neural processes that affect humans. The history and philosophy of romantic love are discussed to attest to its permanence and explore the forethought surrounding love as a universal. This thesis thus first discusses the definition of romantic love and possible explanations for this phenomenon rooted in evolutionary psychology. I review studies of mate choice and preference to examine whether, cross-culturally, there seem to be universal trends. I then discuss the effects of love on the brain and body regarding physiological and neural changes when an individual meets a prospective partner. These sections also include the refutation of common myths pertaining to trends about romantic love. Furthermore, I would like to propose that, if romantic love is universal then its' double-edged quality is universal too, so just as surely as one can fall in love one can fall out of it. If this work serves no other purpose, let it be a solace that the broken heart is also rooted in biological processes as a consequence of love gone wrong thus, though it may not seem so, a broken heart is mendable. Though love is surely a subjective experience, the aim of this review is to identify the universal qualities within love across cultures and time.

History and Philosophy of Love

The oldest documented display of love is called *The Love Song for Shu-Sin* and was found written on a cuneiform tablet from the ancient civilization of Mesopotamia (Kramer, 1988; Mark, 2014). The poem was written around 2,000 BCE and is thus approximately 4,000 years old. It recants the fervent emotions of a bride felt for her

husband, the king Shu-Sin, who reigned over the Mesopotamian city of Ur from 1972-1964 BCE. The writer feels deep affection for her husband and is captivated by him. This poem is also thought to be part of a sacred ritual performed every new year by the king Shu-Sin to bring prosperity to his kingdom. From this point on, the documentation of romantic love came to permeate writing, music, and art.

Empedocles, a pre-Socratic philosopher, viewed Love as a cosmic force that rivaled Strife (Kingsley, 1995). He reasoned that Love bore all elements, which then created all earthly things in their combination. Strife was repulsion and destruction that rivaled Love. These two cosmic forces in tandem then created the cycles in life and the cycle of life itself. Plato, in his lifetime, defined and redefined love in a myriad of ways. In his work, *The Symposium,* Plato uses a character called Aristophanes to explain that human beings were originally creatures that had two faces, four arms, and four legs (Groden, 1960). He explains that human arrogance and defiance towards the gods angered Zeus so much so that he split every human in half and set them apart so that they may have to travel the world to find their missing half. According to Plato, love completes us because it is union with our other half. Plato uses seven characters to explain love and all of their definitions vary. In his later work, *Phaedrus,* Plato renounces love because it carries with it irrational behavior and acts born out of jealousy (Jowett, 2006). Plato's wavering definition and opinion of love well capture the opinions of the modern day individual as well. In one moment, one can adore and desire love, and in the next, they can despise it. Similar to Plato in the time of *Phaedrus*, in Buddhism, the path to enlightenment calls for non-attachment, and romantic love was perceived as a form of attachment and thus could be a source of pain and suffering (Buddharakkhita, 1996). In Buddhist philosophy, romantic love, which could be fueled by envy, desire, and expectations could lead to harm and thus leads away from enlightenment. Siddartha Gautama does not cast out love altogether though. He teaches unconditional love through compassion for all people. Soren Kierkegaard, a Danish philosopher distinguished two different types of love which he called preferential and non-preferential love (Hong, 1995; Krishek, 2008). Much like the Buddha teaches, non-preferential love is loving your

neighbor thus loving all others and objects equally. Kierkegaard says that non-preferential love is endless and an ability that all people hold. Preferential love, which encompasses romantic love, by contrast, is a form of selfishness. Kierkegaard explains that we have preferences for another individual and hold them higher above others because they can make us happy and gratify our needs in some way. But, preferential love is also riddled with expectations and gratification that can lead to chaotic and contradicting emotions, thus is not ideal nor sustainable. Kierkegaard himself was a victim to preferential love and was so convinced of its harm that he left his beloved wife because he knew his preferential love to her, through the guise of passion, was detrimental to the both of them. Through studying these various philosophical views of love, I noticed one commonality. Romantic love was associated with such suffering, despair, and madness. Why then is it so coveted and desired?

Aristotle viewed romantic love as an extension of friendship. He viewed the union of two individuals to a household existing for the purpose of creating life while also enjoying their friendship (Barlett & Collins, 2012). Aristotle may have tuned into the biological purposes of romantic love. Schopenhauer, a German philosopher, argued in the *Metaphysics of Love* that love exists so that humans may reproduce, though he argued that love disguises itself through happiness and agency to carry out this task. Thus, Schopenhauer suggests that we endure the elation and suffering of love because love has an ulterior motive, to allow us to reproduce (1871).

Finally, some contemporary psychologists advocate that evolutionary theory provides an explanation for the existence of romantic love. The theory suggests that romantic love exists for us to find a partner that is not only capable of reproduction but also capable of successfully rearing the offspring. Thus, we pick a partner who in their physical attributes and personality traits are likely to give our children desirable traits and who themselves are likely to weather the storm of child rearing alongside us. Some would argue that this simple explanation takes away from the magic and mystery of love. Romantic love, something so phenomenal, could not be simply a biological process,

could it? Simply put, romantic love is a biological process and all of the excited, ecstatic, melancholic, and somber feelings that come with it are as well. Love lives within the heart and mind to influence the body.

Love as a Science of the Mind

So, how does evolutionary theory manifest in our experiences with romantic love? Well, to reproduce we must first find a prospective mate. How do we decide this? Surely, preferences and 'types' vary from person to person and from one culture to another. Sexual selection, a term Charles Darwin coined, is a well-known theory that is proposed to work within natural selection to encourage reproductive success in humans (Darwin, 1859). Darwin first proposed sexual selection in 1859 and then further elaborated this concept in his work in *The Descent of Man* in 1871. He proposed that there were two mechanisms within sexual selection. Intersexual selection is essentially mate preference: a member of one sex chooses a member of the other sex as their mate based on amicable qualities and characteristics that this prospective mate may hold. Intrasexual selection occurs when members of one sex compete with one another to acquire a mate of the opposite sex. Those who mate and reproduce successfully would then further the representation of their traits in the next generation. Traits that recur successively become more frequent in every new generation. Darwin's ideas were significant to understanding human mate preference and mate choice. Studies of mate preference and mate choice have since then had numerous significant findings, some of which this thesis will delve into in a later section. Accordingly, our preferences in partners, whether physical attributes or personality traits, are considered by us because the drive to reproduce favors the characteristics that will ensure our reproductive success.

Though rudimentary and restricted in a modern day context, Darwin's ideas pertaining to mate choice and mate selection have permeated the study of romantic love and served as the foundation of many studies about the biological nature of love. In the field of evolutionary psychology, romantic love is seen as a means for mate selection and

reproduction (Buss, 1988). Romantic love takes the form of actions that lead to successful reproduction. These acts include, but are not limited to, resource display which demonstrates the credibility of a prospective mate to provide for a partner or their offspring or to bear offspring, exclusivity which includes fidelity and mate guarding, and commitment which resembles self-sacrifice, investment, and care for a partner. Monogamy in humans has been found to yield greater reproductive output and greater survival of offspring relative to other mating forms (Buss, 1988). Monogamy is thus explained to confer messages of investment and commitment to a partner, which thus also contributes to reproductive success and fitness. This claim was studied by researchers attempting to determine the correlation of love and reproductive fitness in the Hadza community of Tanzania, Africa (Sorokowski et al, 2017). The Hadza community is a hunter-gatherer society and was thus chosen as participants in that their lifestyle is one without technological confounds and western preconceived notions of romantic love. An important aspect of this study is that the Hadza couples were in monogamous committed relationships as defined by the length of their relationships and the self-reported intensity of their affection towards their partner. Reproductive success was measured in the number of children the couples had. The results demonstrated that commitment within monogamy was positively correlated to reproductive success in the married individuals. In other words, those who demonstrated higher levels of commitment had children and had more children thus had increased reproductive success. In evolutionary psychology, love is thought to be an adaptation that leads us to actions and decisions that increase reproductive success and fitness (Buss, 2018). In this perspective, the fervid feelings that romantic love inspires and provokes may exist simply to encourage or motivate us to invest in relationships that lead to successful reproduction.

An anthropological perspective suggests that partnerships of romantic love may have developed due to the evolution of human bipedalism (Fisher, 2005). Fisher suggests that the evolution of bipedalism eventually allowed humans to carry children in their arms instead of their backs in contrast to most other primates. The occupation of the arms and hands when carrying children made tasks of survival like foraging, holding food, or

traveling long distances difficult. Partnerships fostered by romantic love, she argues, allowed us to share the responsibility of carrying and caring for the child as well as gathering resources for survival. Humans are social creatures. The increase of human cranial capacity is partly attributed to evolving the creation and maintenance of relationships to take part in a community and strive within that community. This is hypothesized because of the relative increase in the size of the human amygdala, hippocampus, and caudate nucleus, the areas of the brain associated with emotional processing, memory, and reward-motivation systems (Stephan, Frahm, & Baron, 1981; Silverthorn, 2016). The ability to form close bonds such as kinships or romantic relationships allows us to bind together to achieve reproductive success.

Though acknowledging the various definitions of love from culture to culture, a biological anthropology approach views romantic love in similar ways. In this perspective romantic love is theorized to be universal because of its prevalence in various human cultures, it then follows that there may be a biological foundation or explanation for its existence (Jankowiak & Fischer, 1992). Fisher proposes that human neurophysiology has evolved chemical mechanisms that facilitate human pair bonds that lead to the successful rearing of offspring (Fisher, 1994). She suggests that these chemical mechanisms have tangible bodies in the form of hormones and neurotransmitters such as dopamine, serotonin, epinephrine, and oxytocin. This adds a surprisingly bolstering scientific account to "It didn't work out, there was just no chemistry." Recent studies examining the chemical and physical bases of romantic love have found its home in our brains, entangled with our reward-motivational systems, and thus suggest love's influence on humans as a reward that, in turn, motivates our actions (Aron et al., 2005; Bartels & Zeki, 2000; Xu et al., 2010). In looking at the fields of psychology, biological anthropology, and evolutionary psychology, the latter of which arguably serves as the middle ground between the two former disciplines, romantic love seems to have inextricable links to human behavior, thought patterns, and human physiology and evolution. Though varied in interpretation, romantic love seems to have a common defining attribute as an innate human ability that serves as more than just a

feeling or emotion. This review will investigate the physical consequences of romantic love as an innate human ability.

This then brings us to the question, “What is love?” The term romantic love is so called after the Roman Empire in celebration of its splendor thus likening love with magnificence and grandeur. An assessment of the term itself, metaphorical context in consideration, could allow one to argue that much like the Roman Empire, the notion of the magnificence of romantic love is also accompanied by its devastating collapse. A simple Google search defines love as, “An intense feeling of deep affection; a great interest and pleasure in something; or feelings of deep romantic or sexual attachment.” This single search lends sidebar real estate to poems and sonnets from the likes of William Shakespeare to Lord Byron. Below that come popular television shows and movies from Hollywood blockbusters to East Asian dramas. At the moment that I write this, there are more than 2.46 trillion results for the "definition of love". The Wikipedia definition states the following: “Love encompasses a range of strong and positive emotional and mental states, from the most sublime virtue or good habit, the deepest interpersonal affection and to the simplest pleasure.”

There are, of course, many types of love. Love encompasses friendships and family as well as romantic relationships, but this review will focus on romantic love. As such, when using the general term ‘love’ in this review, I will be referring to romantic love. Romantic love, in the context of academia, is defined in many ways but characteristically includes varying emotions, affection, sexual attraction, and preoccupation with the other in the hopes of an enduring relationship (Bartels & Zeki, 2000; Karandashev, 2016). Of course, romantic love is not limited to heterosexual persons or persons in heteronormative monogamous relationships. The key points and studies discussed in this review are relevant regardless of sexual orientation or gender but may function under the assumption of monogamy as an evolutionary adaptation in humans. We will begin our discussion of romantic love by exploring the postulate that love is a universal phenomenon.

Love across Cultures

Whether we are pawns in love's strategic game for reproduction or experiencing love as a divine gift, love is rightfully given the force behind its name because love reaches us all. A 1992 study examined 166 cultures around the world in search of cultural literature alluding to the existence of romantic love to prove love as a universal (Jankowiak & Fischer, 1992). The research team searched through varying societies' central works of literature, from folklore to songs to poems to ethnographic works. The pieces were deemed essential works representative of the respective cultures by the Standard-Cross Cultural Sample (SCCS) database. Where past studies predominantly focused on literature from Europe, this study included cultural works from Sub-Saharan Africa, the Americas, the Mediterranean, Asia, and the Pacific Islands. The research ethnography coders read through copious amounts of literature and looked for expressions of love describing mutual affection, longing, romantic involvement, elopement, etc. They then checked each other's coding results to ensure reliability, dropping any disagreements on the existence of love in cultures where its existence was unclear. After studying the central literature pieces of 166 cultures, they found that 88.5 percent of the societies examined had documented the existence of romantic love. It should be taken into consideration that these pieces were also central works representative of the cultures. Upon revisiting the study, the remaining 11.5 percent was deemed a technical oversight, on part of the coders, which needed further investigation meaning that the percentage may be higher.

Given the amount of research done on romantic love by Western researchers in Western populations, Karandashev (2016) studied romantic love in different cultures of the world to investigate whether love is truly universal or whether love is a western construct. He notes that this is a crucial question since he believes that love may have originated in Greece, India, or the Islamic world. He conducted his research along claims from both sides speaking of love's universality as a biological process and love's absence in non-western areas such as East Asia. Karandashev studied ideas of romantic love by

conducting a comprehensive cross-cultural and historical review of love. He explored how love was described or spoken of in literature to find the meaning of love in the West and East, in great nations and small city-states, and ancient civilizations and modern societies. Karandashev discussed different cultural representations of love across cultures and finds differing definitions from the term's alleged 19th-century Parisian inception, back to 3rd century Hindi philosopher's teachings of love, to Confucian era love in China, to the changing connotations of love in 12th century Medieval Europe until 16-17th century Shakespearean Love. He found that all of the cultures he studied indeed conceived of romantic love as an emotion, though their "rituals of love" differ significantly (2016). Like Jankowiak & Fischer, (1992), he concluded that love is truly universal, though it is learned through cultural norms and is thus culturally specific.

But, if love is universal on some level, could there be certain qualities that characterize it? If love is universal though culturally specific, could these defining qualities then differ from culture to culture? In the additional cross-cultural studies reviewed below, researchers focused on identifying the core attributes of romantic love by conducting surveys asking which statements about romantic love participants agreed with. Examples of these statements are shown in the figures below. A cross-cultural analysis of love in the United States, Russia, and Lithuania with 1,157 participants was conducted through a questionnaire to find these core attributes (de Munck et al, 2011). Across these cultures, five key attributes were identified as critical components of romantic love: sexual attraction, intrusive thinking, love as supreme happiness, finding personal betterment in a relationship, and the willingness to do anything for a loved one. Though respondents in the varying populations studied also agreed with other statements in the survey, these five statements were significant in that they were agreed with across all three of the populations. A replicate study was conducted in China (Jankowiak et al., 2015) to determine whether these same core components identified in the three Caucasian populations would be also true for urban Chinese youth. The 151 participants, regardless of their sex, gave similar responses when asked to identify the core principles they perceived as essential while being in love. This study named the five core principles

agreed upon by all four populations in the two studies discussed. I will use their following shorthand terms to describe the core principles associated with love. Intrusive thinking was the core principle associated with the statement, “I constantly think about the person I am in love with.” Self-actualization was the core principle of, “Romantic love is the supreme happiness of life.” Emotional fulfillment agreed with, “My love makes my partner stronger and a better person.” Altruism was associated with the statement, “I will do anything for the person I love.” Lastly, biology is the term associated with the core principle of, “Sexual attraction is necessary for love.” Another study conducted on South Korean participants was done to bridge the gap between the United States population and the Chinese population (Nelson & Yon, 2018). South Korea was chosen because South Korea historically shares many cultural ideologies with China as well as similar industrialization patterns. At the same time, South Korea also shows strong parallels with the United States both politically, in democracy, and culturally, with the prevalence of Christianity. These affiliations appropriately position South Korea as an "intermediate" society between the West and the East. Nelson and Yon’s study found that the 250 South Korean participants also agreed with the five aforementioned core principles of romantic love. Of course, there is room for expansion for this topic. It would be beneficial to conduct studies such as these in the Middle East, Africa, the Pacific Islands, and other areas. Then we might be able to determine if these five core principles are truly universal.

Love on the Brain

Love may be a universal entity, possibly defined by at least five core principles that characterize its ability to permeate our thoughts. Though this may substantiate love’s universality as a human experience, this attribute is contingent on the idea of love as a mechanism that is inherent in human biology to increase individual reproductive success. Much like love as a feeling, emotion, or psychological experience is universal and has core defining attributes, it should follow that love as an inherent biological process then physically takes a defining form within the human body and mind. This then brings us to

the discussion, what does love look like? How can we identify love? The journey to discovering love's physical form begins in where else but the root of human experience and emotion, the brain.

One of the earliest studies of emotional states and functional MRI (fMRI) showed that participants who self-identified as being deeply in love had significant activation in different areas of the brain when viewing a picture of a romantic partner than when looking at pictures of close friends and family (Bartels & Zeki, 2000). The activated areas of the brain were within the middle insula and anterior cingulate cortex. The researchers were surprised to find that, though the activated areas were within regions of the brain known to be associated with processing emotions, the activation pattern of romantic love was unique from kinship and friendship. It also came as a surprise that romantic love was so limited spatially within the emotional processing region considering the wide range of emotions associated with love. This study identified the unique patterns of love on the brain but did little to explain the meaning of such patterns and their placements. As such, it inspired further researchers to map where love lies.

Researchers studying the neural mechanisms of romantic love and studying the premise of love as a human drive used fMRI brain scans to determine which human motivation system, if any, love affects (Aron et al., 2005). Interestingly, prior studies have suggested that intense romantic love activates areas in the brain, namely the ventral tegmental areas (VTA) that are also activated during cocaine use (Breiter et al., 1997). There seems to be a correlation with the effects of romantic love and cocaine use on the brain, both exhibiting patterns of addiction which work within dopamine reward pathways. Moreover, related studies have shown that being in love inspires behaviors characteristic of cocaine withdrawals like excessive energy, sleeplessness, and loss of appetite (Fisher, 2016). These findings added substantial meaning to the exhausted and clichéd phrase, "Love is a drug". The proposed reproductive goal of love in addition to its proposed universality and the aforementioned studies lead the researchers to hypothesize that romantic love would make its home in the reward and motivational systems in the brain, namely the caudate nucleus, which determines rewards, expectations, and goals,

and the VTA. Aron et al. (2005) used fMRI to image the brains of 17 participants, 10 male and 7 female, who declared themselves intensely in love. Participants were shown pictures of their beloved as the stimulus to elicit the strong feelings associated with love and then scanned their brains with fMRI to determine the areas of the brain that love significantly effects. The fMRI scans indicated the significant activation of the VTA and the caudate nucleus. Furthermore, those who self-reported higher levels of romantic love had greater activation than others in these areas of the brain.

More recently, a similar study was done with Chinese participants to broaden Aron et al.'s (2005) work to include non-Western subjects (Xu et al., 2010). This study demonstrated the same results, namely activation of the VTA and caudate nucleus in those who self-reported themselves to be in intense romantic love. A more recent study also looked at fMRI scans of couples in committed long term relationships spanning 10-29 years in marriage (Acevedo et. al, 2011). The VTA and the caudate nucleus were also significantly activated in these participants. These results indicate that romantic love engages the motivational and reward system of the reptilian brain which facilitates our survival needs and thus suggests that, rather than a feeling, romantic love is a human drive that leads us to its associated emotions (Fisher, 2005). Romantic love, being more than a feeling, is rather a human instinct.

Love in Five Senses

> "Love is of all passions the strongest, for it attacks simultaneously the head, the heart and the senses."
>
> — Lao Tzu

"Love is blind." This is a common -- and arguably erroneous -- phrase that pops up when speaking of romantic love. This phrase is used when someone is ostensibly swept up in the grandeur of love so much so that they seem not to mind outward

appearances or their partner's inner faults. If love is alleged to be blind, what other senses might it ignore?

Olfaction

The sense of smell and the differentiation of odors, called olfaction, is one of the oldest senses in living creatures (Silverthorn, 2016). Smell is based on chemoreception, a physical process wherein volatile molecules bind to receptors in the olfactory and vomeronasal systems that then trigger neuronal responses that lead to perception of smell. Chemoreception is a physiological process that is used to find food, detect hazards, and ensure safety (Pinto, 2011). Recently, the idea of pheromones having a role in human mate preference and mate choice has been a popular conversational point in the realm of romantic love. Pheromones are defined as substances, called ectohormones, which are secreted by individuals to the environment, which are then detectable by another individual belonging to that species. The detection of the pheromones can then elicit a physiological or behavioral response in the detecting individual (Verhaege, Gheysen, & Enzlin, 2013). Pheromones have long been studied in animals where it has been shown that they can elicit behaviors like kin bonding, claiming territory, warding off predators, warning kin of danger, and evoking sexual arousal. Though pheromones could be present in all human bodily secretions, research to date emphasizes the presence of pheromones in axillary sweat. Pheromone preference in humans has been proposed to play a role in mate choice, rooted in our immune system biology, by increasing genetic diversity. This is thought to be done through the sexual reproduction and thus the consequent creation of highly variable major histocompatibility complexes (MHC) and human leukocyte antigens (HLA) in offspring (Wedekind, 1995; Verhaege, Gheysen, & Enzlin, 2013). The MHC-HLA plays an essential role in immunity by recognizing and binding peptide fragments from pathogens and displaying them on cell surfaces to trigger the body's immune response to destroy the bacteria or virus, kill infected cells, and produce antibodies that eliminate the pathogens (Janeway et al., 2001). MHC is related to odor and pheromones in that components of MHC glycoproteins could be secreted in body

fluids like sweat. MHC could also influence the growth of bacterial flora on the skin which thus influences body odor. The explanation of pheromone associated mate choice for MHC-HLA is that novel combinations of MHC-HLA alleles are important factors in immune function and recognition. Essentially, if two individuals with different MHC-HLA profiles reproduce, their offspring may, in turn, possess high MHC-HLA diversity which could benefit them by allowing increased recognition and resistance to the various pathogens encountered by both parents (Chaix, Cao, & Donnelly, 2008). A diverse MHC-HLA profile would grant an individual better chances at surviving and resisting pathogenic illnesses and this increased chance of survival is then reasoned to fuel human subconscious desire to choose a partner by scent who has differing MHC-HLA profiles than our own.

Can this be true? Can humans sniff out their ideal reproductive partners? A dating app called Pheramor launched in 2018 playing on the idea of pheromones and genetic diversity. It asks customers to swab their cheeks for saliva and send it to headquarters for genetic testing to look at 11 "attraction genes", a great proportion of which have much to do with MHC-HLA diversity. Pheramor optimizes relationships by pairing people who have different genetic sequences, playing on the long-standing "opposites attract" supposition and diversification of MHC-HLA profiles. Despite the excitement and promise of finding "the one" through smell, the role of pheromones in human mate preference has been contested since its inception.

In animals, pheromones are detected mainly through the vomeronasal organ (VNO) or Jacobson's organ (Daniello et al., 2017), which is found in the nasal cavity. The VNO is an accessory organ belonging to the olfactory system and thus contributes to the sense of smell. The idea of pheromone detection is highly debated because, though the VNO is variably detectible in some humans, it is non-functional and does not contribute to the human olfactory system. This is because the VNO in humans does not have nerve fibers or sensory neurons and, in addition, no olfactory bulbs have been found to be on the receiving end of the VNO (Trotier, 2011). Thus, though the pheromone sensing organ is present it does not contribute to our detection of pheromones. Though

some studies have shown a correlation with odor, mate preference, and genetic dissimilarity, the debate of mate preference by pheromones exists because the human physiological mechanisms remain unidentified.

Despite the non-operational human VNO, some studies have shown a correlation with mate odor preference and genetic dissimilarity of the MHC-HLA loci in prospective partners and long-time partners. The infamous "sweaty T-shirt experiment" carried out in the 1990s may come to mind (Wedekind, 1995). There were 49 female participants and 6 male participants in this experiment. The male participants wore a cotton shirt consecutively for approximately two days and were instructed to stay away from odor contributing products like body wash or cologne, odor producing foods like garlic or onions, and odor producing activities like smoking tobacco. The female participants then smelled each T-shirt belonging to the males individually and rated them on scales of 1-10 on the categories of pleasantness, intensity, and sexiness. The MHC-HLA loci of all of the participants were determined through genetic testing. This study found that women experiencing normal reproductive cycles rated the odors of men who were genetically dissimilar to them at loci of the MHC-HLA complex as more pleasant than the body odors from genetically more similar men. Cycling women who rated the genetically dissimilar men as more attractive also said that their scents reminded them of past or current partners. Interestingly, women who were on hormonal contraceptives showed the opposite pattern, rating the odors of genetically similar, rather than dissimilar, men as more pleasant. Given the purpose of the pheromones argument, this finding may pose a consequence for women on contraceptives. Choosing an MHC-HLA similar partner while on contraceptives could allow for an offspring's decreased immune function in creating and passing on a less diverse MHC-HLA profile and thus decreased immunity to various pathogens and other immune challenges. The study suggests that contraceptives may interfere consequently with natural mate choice. Further, the researchers also noted that couples who had recurrent failed pregnancies using in-vitro fertilization or embryo tubal transfer, those who often had spontaneous abortions, and those who had offspring with lower birth weight also tended to be more similar in their MHC-HLA complexes. A

later study conducted by Wedekind and Furi (1997), focused on the purpose of diverse MHC combinations and heterozygosity, found the same results. In that study, female participants favored odors of the males with whom they had significant MHC differences. I would argue that these experiments had some flaws. Though the sample sizes for each experiment were large, the participants were all university students of Swiss-German descent, which is not indicative of the greater population. The rating categories of pleasantness, intensity, and sexiness also had no defining markers or definitions for the women participating in the experiment. The female participants were also told the purpose and predicted results of the experiment which may have allowed for unintended participant bias. Despite this, you could see how a study such as this, in exploring the dramatic consequences of pheromones, would bring the idea of mate choice by smell into the public sphere.

Another similar sweaty T-shirt experiment conducted in 2002 showed contrasting results (Jacob, 2002). Six male participants wore a cotton T-shirt for two consecutive nights, and 49 female participants then smelled the shirts belonging to the males individually and rated them in the categories of pleasantness, familiarity, intensity, and spiciness. The men, like in the aforementioned experiment, took precautions not to taint their scents with other odorous products, foods, or activities. The female participants were asked which odor they preferred and which odor they least preferred if hypothetically they had to smell it frequently. For each woman, the male with the preferred odor had significantly more similar MHC-HLA profiles to her than did the male with the least preferred odor. These results thus contrast the previous sweaty T-shirt studies relating to odor and mate choice. Other studies have also contested the idea of odor-pheromone-based mate preference. A 2008 study directly measured the MHC-HLA profiles in 30 European-American couples and 30 African couples as compared to random pairs of individuals (Chaix, Cao, & Donnelly, 2008). This study found that the European-American couples had more dissimilar MHC profiles as compared to the randomly paired individuals. By contrast, the African couples showed more MHC similarity than expected, compared to random pairs. This then raises the question of

whether and why MHC mate choice might operate differently in different ethnic and geographical contexts. A 1997 study done with 411 Hutterite couples found similar but debatable results (Ober et al., 1997). The Hutterites are a community of reproductively isolated North Americans of Austrian-German descent. The researchers genetically tested the participants and found that the couples shared more statistically significant dissimilar HLA haplotypes with each other than by random chance. In the same year, a study of HLA haplotypes of 11 South Amerindian tribes was done to test the same hypotheses (Hedrick & Black, 1997). There were 194 couples collectively from the different tribes that spanned across South America. The tribes were physically separate, spoke different languages, and held no history of exchange with one another. The couples were genetically tested for HLA haplotypes and the results found no significant evidence for negative assortative mating thus no evidence of mating based on MHC-HLA dissimilarity. Ober et al. acknowledges these differences and states that it is possible that mate choice by MHC-HLA diversity may be present in communities in which there is already limited variation in MHC-HLA diversity, thus dissimilarity could further be achieved (Ober et al, 1997). He mentions that there may be some subconscious social influences in mating. He also states that MHC-HLA similarity avoidance may not be present in outbred populations because those belonging to outbred populations have more chances to meet different people with similar MHC-HLA profiles as themselves and are under no reproductive restrictions.

The idea of being able to sniff out an ideal partner is fascinating and intriguing yet odd, but there is no valid evidence for its consistency between different groups of people, barring those of European and Caucasian descent, and no evidence of its physiological mechanisms through the VNO. This is complicated even more when considering that mating for MHC-HLA dissimilarity may be true for those of Caucasian descent but not for Africans. In addition, though the sweaty T-shirt studies accounted for odorous products, foods, and activities, they did not account for the bacteria that live on human epithelium and often contributes to our scents, especially in our axillary regions. This bacteria could contribute to our human scent undetectably and thus their odor emissions

can mistakenly be counted in an individual's natural scent. Such an issue adds another layer of complexity in regards to bacterial interference of human pheromones and scents, as well as further implications for bacterial flora and odor preference in tandem.

As Ober et al. mentions, there may also be social influences or learned behavior associated with scent perception. For example, an individual may be raised around a certain scent thus has normalized and ignores its presence when others may find that scent unpleasant. The smell of gasoline is an example. I, myself, find the smell of gasoline comforting, like some others, because it reminds me of my childhood in my home country while others may not have any sort of attachment to the smell of gasoline and think it awful. This is not to say that a partner who smells like a childhood memory will not be the ideal mate, barring their other odors. The point is to emphasize that the "pleasantness" of smells may vary from one person to another and thus not be necessarily reliable when picking an ideal partner. There is also another question of the role of colognes and perfumes. Such products are intended to make us smell better, though if pheromones are to be a factor in mate choice, the use of topical scents can arguably interfere with natural mate choice. Admittedly, the promise of scent and pheromones in mate choice is attractive despite the complexities and uncertainties associated with it. If someone would want to test this out for themselves, all it takes is a $19.99 cheek swab and a $10 monthly subscription to Pheramor.

Taste

Closely related to our sense of smell is our sense of taste, otherwise known as gustation. An evolutionary perspective suggests that the sense of taste developed in humans to allow us to distinguish between good and bad food. For instance, foods that were perceived as sour or bitter were thought to be rancid, poisonous, and ultimately inedible. Foods that were salty or sweet were thought to be nutrient dense and thus beneficial to consume. Could gustation possibly play a role in falling in love?

If love had a flavor, what would it be? Sweet like honey or candy maybe? This is a well informed guess if songs, poems, and novels serve as reasonable points of

reference. For example, the iconic song *I Can't Help Myself* begins with, "Sugar pie, honey bunch. You know that I love you (Holland, Dozier, & Holland, 1965)." Other common terms of endearment also include "sweetie", "sugar", and "honey". Researchers who were also curious about the common association of love and sweetness explored if love truly had an influence on taste perception (Chan et al., 2013). They conducted a two-part study, first establishing the association of sweetness with love and then studying the perception of sweet foods while inducing the feeling of love. The first portion of the studies consisted of surveying 37 participants about what tastes they associated with various emotions and 102 participants who wrote down flavors associated with different emotions including love. Statistical analysis showed that love was strongly associated with terms for sweetness and the taste of sweetness. In the second portion of the study, 95 participants were asked to come in for a false consumer taste preference and visualization study. They were asked to consume water as a palate cleanser and then asked to write about a time when they felt romantic love. Then, the strength of their feelings was measured through a point scale survey. The participants then ate chocolate for one minute and rated how sweet, spicy, bitter, and salty it tasted. The results showed that those scoring more highly on feelings of romantic love perceived the chocolate to taste sweeter. The researchers suggest that the love-sweetness effect may be facilitated by our neural reward system. The anterior cingulate cortex is activated both upon seeing pictures of a romantic partner and upon tasting sugar, thus the stimulus of one could provoke the other (Bartels & Zeki, 2000; Chan et al., 2013).

Interestingly, further studies examined the effect of sweetness in non-established or hypothetical relationships (Ren et al., 2014). Participants in the "sweet" test condition group were provided with sweet foods and drinks like Oreo cookies and soda while participants in the control group were given salt-vinegar chips and water. These foods were consumed slowly through a survey period which included hidden questions aimed at analyzing a hypothetical relationship and the traits of the prospective partner in that relationship. The participants who consumed the sweet foods had more positive evaluations of the hypothetical relationship and the prospective partner, even expressing

romantic interest. The researchers concluded that experiencing sweet tastes may make individuals likely to perceive a potential romantic relationship more positively. Perhaps our metaphors are correct; perhaps love is truly sweet.

Touch

Touch is a somatic sense that recognizes mechanical, chemical, and thermal stimuli that are near or contact the surface of the body, the skin (Roudat et al., 2012). Touch is essential to our survival in recognizing harmful stimuli. Tactile discrimination, or touch, acts as the bridge to different types of somatic senses like the perception of temperature, proprioception or awareness of the position of the body, and nociception which is the perception of pain (Silverthorn, 2016). Touch facilitates emotional growth and development, personal communication, and social interactions (Gallace & Spence, 2012). Touch helps to grow interpersonal relationships and promote emotional and physical closeness thus helping us to bud and satisfy romantic love. Romantic love and the experience of being in love also affect the sense of touch by changing lovers' perceptions of pain. Does love then, truly make us stronger?

Try to recall a romantic comedy movie or television drama. There is a likely chance that the movies that come to mind have that pivotal "accidental" touch moment -- a scene where hands accidentally brush against one another, or some variation of that. Despite the context of a romantic screenplay, this casual touch may have an effect in any casual and real-life situation. A study in 1976 was done on library book patrons and librarians who 'accidentally' brushed hands with the patrons checking out books as they handed back their library cards (Fisher, Rytting, & Heslin, 1976). The librarians were asked to accidentally and casually brush hands with half of the visitors checking out library books. There were female and male patrons and librarians included in the study. After the interaction, the visitors, unaware of the true purpose of the study, were asked to fill out questionnaires about the library facility and services provided. Those whose hands were "accidentally" brushed by the librarians gave more positive reviews of the library and their specific librarians, regardless of whether they remembered the accidental

interaction or not. This study then opened the door to further studies of the affective effects of touch.

In a questionnaire study done with 295 participants, physical affection, in the form of hand-holding, hugs, and back rubs, was found to be highly correlated with satisfaction in relationships and satisfaction with a partner (Gulledge et al., 2003). Physical affection among partners was also found to more facilitate conflict resolution. Touch, in the form of affection, has also been found to lower cardiovascular reactivity to stressful events and thus suggests the benefits of having lifelong affectionate partnerships (Grewen et al, 2003). In this study, one partner from a cohabitating couple, was tasked with public speaking under stressful conditions. For the experimental set of participants, partners were instructed to direct physical affection to the speaker in the 10 minutes before they began their talk, in the form of hand-holding and hugs. For the control set of participants, partners were instructed to give no physical affection to the speakers and instead to just sit quietly with them before the task. The study found that in the group that received pre-stress partner contact, there were lower spikes in heart rate and lower overall blood pressure changes during the public speaking task than in the control group, thus emphasizing the comforting effect of affection from a loved one in mitigating stress. Similarly, a study testing the effects of couples' interactions on psychosocial stress and hypothalamic-pituitary-adrenal autonomic response found that physical interactions with a partner in the form of a neck or shoulder massage before stress tests resulted in lower cortisol and heart rate responses (Ditzen et al., 2007). Physical touch proved to be more effective than either no interactions or verbal-only interactions from a partner. The authors emphasized the beneficial effects that interpersonal touch may have as a direct protective effect during times of stress.

In regards to the possible physiological consequences of love, we have delved into the two extremes of love -- love as a force that elicits happiness and love as an omen that carries anguish (though it should be noted that love can cross the boundaries of emotions). The previous studies investigated how touch in the form of physical contact can affect our response to stress but can it affect our perception of pain? Love has been

studied as a modulator of pain, affecting our perceptions of physical pain. This phenomenon is reasoned to be the result of the closely linked areas of love and physical pain in the human brain (Tamam & Ahmad, 2017). The question remains, does it decrease our pain perception, or increase it? Being in love elicits the former. A study compared the analgesic effects of holding a partner's hand versus looking at a partner's picture during painful thermal stimulations and found that pain perception was decreased in both situations but even more when only viewing a picture of the partner without hand-holding (Master et al., 2009). A similar study examined the effects of pain perception when the participants' loved ones were or were not near the subject during pain stimulations (Tamam & Ahmad, 2017). The results showed that during laser-induced heat stimulation, the presence of a partner from a romantic relationship decreased the subject's pain threshold much more than the presence of parents or close friends. A study further elaborating on the pain-modulating effects of love found that viewing pictures of a partner while in pain also activates the reward systems of the brain (Younger et al, 2010). This study distinguished the analgesic effects of the reward system from the analgesic effects of simple distraction, the former of which, done by viewing a picture of the loved one, resulted in greater decreased pain perception. The researchers also suggest that this reduction of physical pain during activation of the reward system allows humans to pursue their important goals despite physically painful circumstances. There may also be a physical basis for sharing pain with a partner. A study of empathy in couples found that seeing themselves or their partner in pain greatly activated their own pain matrix more than viewing strangers in pain (Cheng, 2010).

The physical benefits of romantic love marvel tangible experiences sometimes overlooked by love's emotional force. The sense of touch and love have an intricate and complex relationship that may involve the entire body as tactile sensation readily waits for stimulus across our skin to communicate to the brain which thus influences the body. As these studies have shown, being in love can mitigate stress and decrease pain perception. In this way, I do believe that love can make us stronger.

Hearing

The ear has two main tasks, balance and hearing. Hearing, or the perception of sound, is near essential for all creatures that can hear. Sound perception can communicate dangers and enjoyment. Sound perception also facilitates communication between individuals. The widespread human activity relating to sound and hearing that I call into question here is the creation and enjoyment of music. Could there be a reason why declarations of love and heartbreak alike are put to music? As a possible human universal, does music or the ability to create music serve a function in our biology? For an art so prevalent and celebrated, there is not much empirical evidence associating music with romantic love. From an evolutionary perspective, it is interesting to note that few animal species can make music which is defined as harmonious ordered and organized sound. With regards to vocal capabilities, humans, birds, and whales may be the most known. In primates, music and vocal displays can be seen in the drumming of great apes and the calls of gibbons, though there is no evidence of vocal learning or complex vocalizations in primates other than humans (Fitch, 2005). Fitch suggests that vocal capabilities and complexity came as a byproduct of the large vertebral canal of modern humans (2005). The neurons housed here are motor neurons that control respiratory muscles thus facilitating greater control over breathing, a necessity in singing. The archaeological record suggests that flutes may be some of the oldest and most common instruments dating to approximately 40,000 years ago. But did the ability to make music serve an evolutionary advantage? If they truly have an adaptive advantage, I imagine that the greater population should be musically inclined. Though, it can be argued that making music is a learned behavior, like learning to play an instrument or taking vocal lessons. It could be that musical virtuosity has no adaptive function as many traits do not necessarily hold evolutionary functions. Proclivity for music may have developed as a by-product of language.

A popular theory is that musical inclination serves a purpose in sexual selection as a courtship mechanism (2001). Evolutionary psychologist Geoffrey Miller calls on Darwin's' ideas of sexual selection in which Darwin likens bird songs' role in

reproductive fitness to human song. Miller suggests that, like many complex biological adaptations, music is universal and so too its enjoyment. Music involves human memory capacity and music capabilities are held in certain areas of the human brain. Music also affects mood and evokes emotion thus affecting our minds and bodies. Miller argues that music serves no ostensible survivability function as our ancestors dancing and making loud noises do not aid their discretion from predators. Yet music is prevalent thus it must hold some hidden purpose. Music, like art and language, is behaviorally complex and special to humans because of our intricately made complex brains. Miller speculates that musical capabilities are honest signals of fine motor control and coordination in voice control and manual dexterity. Performance and mastery, he suggests, could indicate intelligence in determining patterns since rhythmic patterns are essential in music. It could also indicate social intelligence in that a performer must understand their audience's enjoyment, or lack thereof, and then act in response. The enjoyment of music creates physical responses in our auditory systems and activates recurrent neural networks. Miller proposes that musical capabilities, including the behaviors and physiology needed to create and respond to music, are a biological adaptation, which, when displayed, indicates cognitive and emotional intelligence, and fitness. A recent study tested this hypothesis. Musical performance quality (MPQ), as indicated by improvisations on the violin, saxophone, and drums, was perceived by participants in the study by attaching mate value and preference to the musicians (Madison, Holmquist, & Vestin, 2018). MPQ occurred on the three levels of beginner, intermediate, and professional. Their performances were rated by the participants on the mate value scales of intelligence, health, social status, and parenting skill. In addition, they were also rated on the mate preference scales of dating, intercourse, short-term relationship, or long-term relationship. The musicians' true appearances were not seen to control for the effect of facial attractiveness in participant ratings. The results showed that there was a general increase in mate value ratings and MPQ in both sexes, though MPQ affected women's ratings more than men. Women specifically preferred long-term relationships with those of higher MPQ and associate higher MPQ with intelligence. Though suggestive, the

results of this study were specific to women only and do not completely support the evolutionary adaptational function of music.

Another large study tested three predictions that stem from Miller's proposition that music creation and appreciation are associated with sexual selection in humans (Mosing et al., 2015). First, if music serves some role in courtship displays, then those who are musically inclined should have greater mating success. Second, if musical ability signals something about genetic quality or cognitive ability. then those with greater musical abilities should display some higher cognitive abilities. Third, if musical capabilities evolved as a courtship mechanism that are honest signals of genetic quality, it should be heritable thus a positive correlation between genetic quality and musical ability should exist. This study was multifaceted and included over 10,975 participants ranging from 27 to 54 years old who differed in levels of musical ability. Measures used for assessing the first hypothesis were the number of sex-partners, age of first intercourse, sociosexual orientation, and the number of offspring. Sociosexuality can be defined as an individual's willingness to participate in sexual activities outside of a committed relationship. To address the second and third hypotheses, intelligence, reaction time, and height were assessed. Contrary to the first prediction, those with greater music ability scored lower on measures of mating success. There were correlations with musical aptitude and intelligence, reaction time, and height in females only. With the inclusion of the participants' families, genetic testing showed varying levels of heritability in musical ability, 57% for males and a rather nonsignificant 9% for females. It seems that there is little evidence to support the evolution of musical capabilities for sexual selection, though it may play a factor in indicating higher levels of intelligence. It is still a wonder that music, pervasive in humanity, simply serves no biological purpose other than for our enjoyment. But therein may lie its beauty.

Vision

Much to the disappointment of hopeless romantics and those alike, love is not blind. Primates, like ourselves, commonly rely on vision above the four other senses. The

evolution of vision in most primates is characterized by the development of trichromatic color vision, which essentially allows us to create mental images of our environment, three-dimensional in color and figure (Kawamura, 2016; Silverthorn 2016). Vision or eyesight is significant in the detection of predators, dangers, food, and ultimately mates. How could a sense so vastly relied upon be overlooked in something as momentous as falling in love? There are physical cues that our vision relays in the consideration of an ideal mate, the most studied being body ratios and symmetry. Though some may argue that looks are a rather shallow means of mate selection, this review of studies is not to claim its importance above all. The aim of this review is to explore the existence of qualities deemed physically attractive and why they are called as such in an evolutionary biological context. For example, a study was done to determine the most important characteristics or preferences when considering a mate. Ranking in fourth place for male and female participants, was the preference for being physically attractive (Buss & Barnes, 1986). In the first moments that we lay eyes on someone that could be our mate, what physical attributes do we consciously or unconsciously notice?

Body Ratios

Body ratios in regards to physical attractiveness have much to do with reproduction. A waist-to-hip ratio (WHR) is a measurement of the waist divided by the measurement of the hips. This attribute is presumed to be telling of female reproductive capability and thus is suspected to contribute to attractiveness. WHR can indicate reproductive capability in that a higher WHR indicates reproductive age and proper endocrinologic status that supports reproduction (Singh, 1993). A lower WHR is associated with higher levels of circulating estrogen in the body, and higher WHR is associated with lower levels of estrogen and higher levels of testosterone. The latter resembles women who have polycystic ovarian syndrome (PCOS), a hormonal disorder that leads to complications in releasing eggs, thus making pregnancy extremely risky or difficult. The endocrinologic levels associated with PCOS also bear resemblance to other female reproductive conditions, namely infertility. A high WHR has also been shown to be a predictor of heart disease and diabetes thus a cue of overall health (Singh, 1993).

The ideal shape of the female body has been a point of discussion within mate-preference studies. A study in 1980 attempted to investigate this by examining the body ratios of magazine models and Miss America competitors whose average WHR resulted to be 0.70 in 1940 and 0.68 in 1987 (Garner et al., 1980; Singh 1993). Singh (1993) investigated whether WHR truly affected women's perceived physical attractiveness. She presented participants with 12 different drawings of a woman's figure varying in WHR from 0.7-1.0. The participants were then asked to rank which figures they considered most attractive. Singh's study identified the preferred to be 0.7 in WHR (1993). In a supplemental survey, the participants perceived this woman with the 0.7 WHR ratio to be attractive, sexy, and healthy. This result was also replicated by other studies (Furnham, Tan, & McManus, 1997; Hens, 1995). A more recent study conducted on a Polish population further corroborated these findings (Koscinski, 2014). Men were asked to rank the simulated silhouettes of a female figure with different WHR. The simulated silhouette was of a three-dimensional woman created from the composite images of real women who qualified as having average healthy body measurements as defined by the World Health Organization. Algorithms were then used to create versions of the same simulated woman having different WHR ratios. Confounding variables having to do with other aspects of appearance, like clothing or hair length, were removed. The study found that the men preferred silhouettes with WHRs of 0.65-0.75. A similar study was done to compare the preferences of American versus Hadza men, thus giving a Western and non-Western perspective (Marlowe, Apicella, & Reed, 2005). The results showed that while American men preferred a WHR of 0.68, Hadza men preferred a higher WHR of 0.78. The studies aforementioned and a few others point out that WHR is relevant because it indicates female weight and weight distribution in regards to reproduction (Swami, 2007; Sugiyama, 2004).

The biological explanation for this attractiveness preference lies within human reproduction. During puberty, the sex hormone, estrogen, allows the body to develop secondary sexual characteristics. The widening of the hips is one of the changes that occurs that allows women to give birth to children, thus calling attention to the waist-to-

hip ratio. This aspect of human birth is important in the human evolutionary process as humans are born with more developed and large heads which wider hips can better accommodate during birth (Rosenberg, 1992). A narrow waist also visually relays the message that a woman is not pregnant and thus is capable of becoming pregnant. Women with higher WHR ratios, commonly associated with being overweight, could have trouble becoming pregnant or have complications carrying the child to term. Pregnancy complications in these cases can include gestational diabetes, recurrent miscarriage, and preeclampsia for the woman and birth defects, impaired growth, and childhood obesity and asthma for the child (Pregnancy and Obesity, 2020; Singh, 1993). A low WHR, commonly associated with being underweight, could also present challenges with becoming pregnant or having a healthy pregnancy. Premature births, common in underweight mothers, result in babies not fully developed in which many complications can occur with the brain, gastrointestinal tract, metabolism, blood, and immune system (Premature Birth, 2017; Singh, 1993). The extremes of low WHR and high WHR are thus associated with risks in reproductive capabilities and offspring viability and success. Further evidence for the importance of WHR as a salient cue of the dimension of attraction is found in the eye-tracking studies of Dixson et.al (2009) which analyzed the visual fixations, dwelling time, and initial fixation of men who looked at front-posed images of a woman with manipulated WHR and breast size. The manipulation in the image was done to account for natural variance in the greater population. The female figure ranged in WHR of 0.7-0.9 and breast size of small, medium, and large. The eye-tracking system measured eye position and eye movements in the men's assessment of the female figure. The results showed that visual fixation occurred longest in the breasts but first in the waist. Overall there was significantly more fixation on the breast and waist than the face or lower body areas. Most notable was the finding that, through a supplemental survey, men rated the figure with 0.7 WHR as the most desirable and most attractive regardless of breast size. Thus, despite breast size catching the most attention, WHR was rated the most important determinant of body attractiveness.

As men look at WHR in women, women look at shoulder-to-waist ratio (SWR) or waist-to-chest (WCR) ratio in men. Braun and Bryan (2006) argued that on a man, broad shoulders and a relatively smaller waist would be perceived by women as a sign of physical strength and dominance and therefore would be found more desirable as an indication for their ability to provide protection to partners and offspring. In a study of 106 males and 134 females, photos of male targets were viewed with manipulated SWR ratios to account for varying SWR in an actual population. From the photos, the male and female participants rated the target male via questionnaire on facial attractiveness, body attractiveness, and weight. Female participants expressed a preference for the manipulated photos of the male target with lower SWR ratios, meaning the 'V' shaped broad shoulders and small waist. This desirability was also correlated with increased ratings on physical strength, dominance, and perceived agreeableness.

Another study assessed female preference for WCR ratios in males. Maisey et al. (1999) hypothesized that WCR is of consideration since broad shoulders, a broad chest, and a small waist is indicative of muscle development and growth in the upper body and thus physical strength. In the study, 30 female participants rated photographs of 50 males that were manipulated to represent varying WCR ratios. WCR was also tested against BMI and WHR to determine the dominant factor in attractiveness amongst the three. The researchers found that WCR was the most important determining factor in perceived male attractiveness accounting for 56 percent of the overall variance. BMI and WHR proved to be insignificant. A more recent study, mirroring the procedures of Maisey et al. (1999), standardized WCR in specific numbers and found that 0.7 was the WCR rated the most desirable by female participants (Garz et al., 2017). It seems that body proportions may matter to both women and men in determining a mate.

In this section, we looked at body proportion preferences and their theorized evolutionary significance. This research is just a small fraction of many different studies on vision, physical attractiveness, and preferences. For example, there have been many studies that have investigated the evolutionary significance of body and facial symmetry, averageness, masculine and feminine traits, and even skin and hair health. As with the

rest of the senses, much more research has been done than what is reviewed here. This area of research is truly fascinating and applicable to this study, though the sheer volume of research is out of the realm of this article. I have discussed the effects that love can evoke on the body as evidence for its possible universality and biological function. This leaves us then to wonder about love gone wrong, which may be the most feared and resented yet also the most cross-culturally documented experience of romantic love.

Lovesickness

> "Love is so short, forgetting is so long."
>
> — Pablo Neruda

What may arguably be the most perplexing and maddening aspect of romantic love is the destruction it can bring. I have explored love as a human drive and as a base instinct, therefore heartbreak, being the adversary of love, must be more than just fleeting emotions. Heartbreak too has physiological consequences on the body and mind. The broken-heart syndrome might be the most extreme of the physical consequences of love gone array. Broken-heart syndrome, or "stress-induced cardiomyopathy" is caused by a period of intense emotional or physiological stress but so termed because of its catatonic effects on the body and mind (Shah et al., 2012). The pain associated with heartbreak is speculated to be the result of surges of catecholamines from the simultaneous activation of the sympathetic nervous system and parasympathetic nervous system. These systems are both part of the autonomic nervous system and act as opposing forces in our body. The sympathetic nervous system is activated during stressful or threatening situations to make the body alert. The parasympathetic nervous system is activated to calm the body. The simultaneous activation of both these systems while experiencing heartbreak is speculated to trigger a complex cycle of hormones that translate into physical pain in the body. An fMRI study following breakups found that brain activity after heartbreak looks similar to that associated with love, though with a few catches (Fisher et al., 2010). Participants who were recently rejected or separated from their partner had significant

brain activation in the VTA, nuclear accumbens, prefrontal cortex, the forebrain, and the insular cortex. The VTA, as we have discussed, mediates reward and motivation. Researchers posit that the activation of this area in both happy lovers and dejected lovers signify that the dejected lovers are still quite in love and their reward centers are waiting on their ex-lover to return. Some of these other areas, e.g., nucleus accumbens and prefrontal cortex, are associated with drug cravings and withdrawal, thus highlighting the similarity in neurophysiology between love and addiction. The forebrain is activated in emotional regulation, thus acknowledging the wide range of emotions felt in the despair of heartbreak. The insular cortex is associated with the regulation of the autonomic nervous system. This finding in the insular cortex provides some evidence for the aforementioned claim of the role of the autonomic system in easing heartbreak. This area of the brain was hypothesized to be activated in dejected lovers because it is active in the experience of psychological pain.

Working on the premise that love is a biologically inherent human capability, Boutwell et al. (2015) suggested that all humans are capable of enduring heartbreak. They argued that we are all equipped with the "mental hardware" to facilitate both falling in love and falling out of love. They theorize that because almost half of all marriages end in divorce, there have to be some adaptational behaviors humans have acquired to push past the dysphoria that heartbreak brings. They call this the "Mate-Ejection Model" for the heartbroken and the heartbreaker. The mate ejection model is described as a method for the redistribution of resources to other prospective partners. In the heartbreaker, this would be the realization that the current relationship is not beneficial in some shape or form to their livelihood. In the heartbroken, it is the 'letting go' stage, the realization that dwelling on the past relationship serves no purpose. Upon examining cross-cultural divorce and separation data, Fisher (1994) suggests that breakups follow a trend related to offspring survival. In finding that divorce and separation commonly occur four years into a marriage, a point in time that parallels the four years between human successive births in some non-contraceptive females, she proposes that this timeframe reflects an ancestral human reproductive strategy to pair, reproduce, and stay together

through the highly dependent infancy of a child. She also proposes that the ability to get over heartbreak, the physiological processes associated with healing from heartbreak, came about to facilitate moving on with another partner and thus creating varied offspring. She suggests that this cyclic process created human serial monogamy. There is no doubt that a broken heart is painful, but it would certainly be devastating to individual reproductive success if every heartbreak ended any future attempt of finding love and continuing genetic lines. Nonetheless, this is much easier said than done.

How do you heal a broken heart? This may be a more crucial question than the existence of love itself. Talk it out with family and friends? Find a new partner? Find new hobbies and keep yourself busy? Remove this person and any trace of them from your life? Maybe just time and patience? Here, I discuss the validity of these customary approaches and their results.

In a questionnaire study of post-breakup emotional adjustment, researchers found that higher levels of reflection on negative aspects of a relationship immediately after a breakup resulted in lower levels of emotional adjustment one month after the breakup (Fagundes, 2012). Given this finding, one may suggest that we should avoid recounting the painful circumstances and negative emotions associated with the breakup too often, as it makes way for slower emotional adjustment. Don't relive the pain and hurt if unnecessary. If friends or family ask about the breakup, maybe round them all up and talk about the catastrophe in one go rather than repeating the story and putting yourself through the emotional turmoil over and over. In addition, Saffrey and Ehrenberg (2007) found that rumination by means of brooding and regret resulted in negative emotional adjustment 3 months post-breakup. They also found the reflection of the relationship in a positive matter, such as practicing gratitude or acknowledging personal growth within the relationship, resulted in positive emotional adjustment. They suggest that dwelling on the negative aspects of a relationship will lead to lower levels of emotional adjustment or slower emotional adjustment. Their findings also suggest that reflecting on the relationship in a positive light will lead to quicker and higher levels of emotional adjustment. Given the findings of these studies, to facilitate a quicker and more stable

emotional healing process, I advise refraining from dwelling on the negative aspects of a relationship and the breakup that proceeds it, and instead focusing on the growth and learning that developed from it.

Bowlby (1979), a pivotal psychologist of the mid-20th century who was an early pioneer of the attachment theory, suggests that in order to adjust to the loss of any attachment figure, one must realize the functions this person served and learn not to rely on them any further. The act of missing and pining for an ex-partner is an example of the body and mind longing for whatever function this person served, be it emotional support, physical affection, friendship etc. This may explain the search for quickly acquiring another partner after a breakup, commonly termed the "rebound". I argue that this method serves no long term purpose and has no endurance power unless the deep emotional ties and other reliances from the past relationship can be found adequately within a new partner. With that in mind, serious attachment in emotional connections and physical dependencies can take months or years to develop and negotiate, especially those of committed relationships. This may explain why it is commonly suggested to practice self-love after a breakup. Learning how to love yourself, learning to be okay with being alone, learning to be independent of someone with regards to emotional or physical needs removes the functions of that ex-partner and thus allows for emotional adjustment and thus healing.

An explanation of the method of keeping yourself busy, finding new hobbies, or rediscovering old hobbies may be rooted in the physiology that being in love inspires. Love is associated with increased levels of dopamine and oxytocin, so finding activities that increase these happy hormones may help facilitate healing. A great hobby to add would be some form of exercise. In addition to increasing physical health, regular exercise reduces depression, anxiety, and negative moods by increasing cognitive function (Callaghan, 2004). The improved physical benefits of regular exercise also improves self-esteem. Increased blood circulation to the brain from exercising coupled with the activation of the hypothalamic-pituitary-adrenal axis (HPA) creates a milder reactivity to stress and thus produces better moods. This physiological change is likely

due to the HPA association with the limbic system, the amygdala, and the hippocampus. These specific areas of the brain facilitate emotion and motivation, response to stress, and memory creation.

Fisher (2005) recommends that to move on from someone who has broken your heart, you must remove all traces of them. This includes gifts, mementos, pictures, letters, or text messages. She reasons that keeping reminders of someone will, to some effect, cause those brain areas to activate from when you were once in love and thus makes it that much harder to let go. Then one day, the melancholy feelings and the dwelling will subside. Sometimes all at once and sometimes so gradually that you may not even notice.

I have discussed the biological purpose of love as a means to increase individual reproductive success. If every broken heart ended a genetic line then the human species would truly be in danger. Falling in love is an innate human ability and thus healing from it is too. Finding love many times over is quite possible as well. If this work serves any solace, let it be this. As surely as one can fall in love, one can fall out of it.

Conclusion

Romantic love, for most, may be essential to the human experience. Stories and songs of love are evident in every culture since oration and documentation has existed. Love is as healing as it is destructive. Love is as coveted as it is spurned. There is a pervasive human fascination with this thing called love that has allowed its permeation through time. This review of romantic love explores its cultural universality as evidence for its biological universality. Romantic love exists to motivate us to create the bonds and relationships that increase our reproductive success and fitness thus our own genetic continuance. I explore the physiological experience of love through the five senses and in the brain as evidence that love is more than just a feeling. Our whole body is affected when falling in love or finding someone worthy of it. To love and to be in love is a human drive. I then discuss heartbreak and the amelioration of it, an unfortunate byproduct of romantic love gone wrong. The study of romantic love and heartbreak is

indeed fascinating and further studies of interest would be of romantic love in our modern technological age, through screens and pictures. In discussing the biological functions and effects of romantic love, I find another seemingly universal truth. As surely as one can fall in love, one can fall out of it. This is not to take away the magic that is love but to bring light to all the wonder that it is. Love affects the body and mind in such complex and intricate ways. Love makes us act. Love makes us listen. Love makes us stronger. To love and love over again will bring novel experiences and even more magic.

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